Study of ϕ-N interaction at LEPS2

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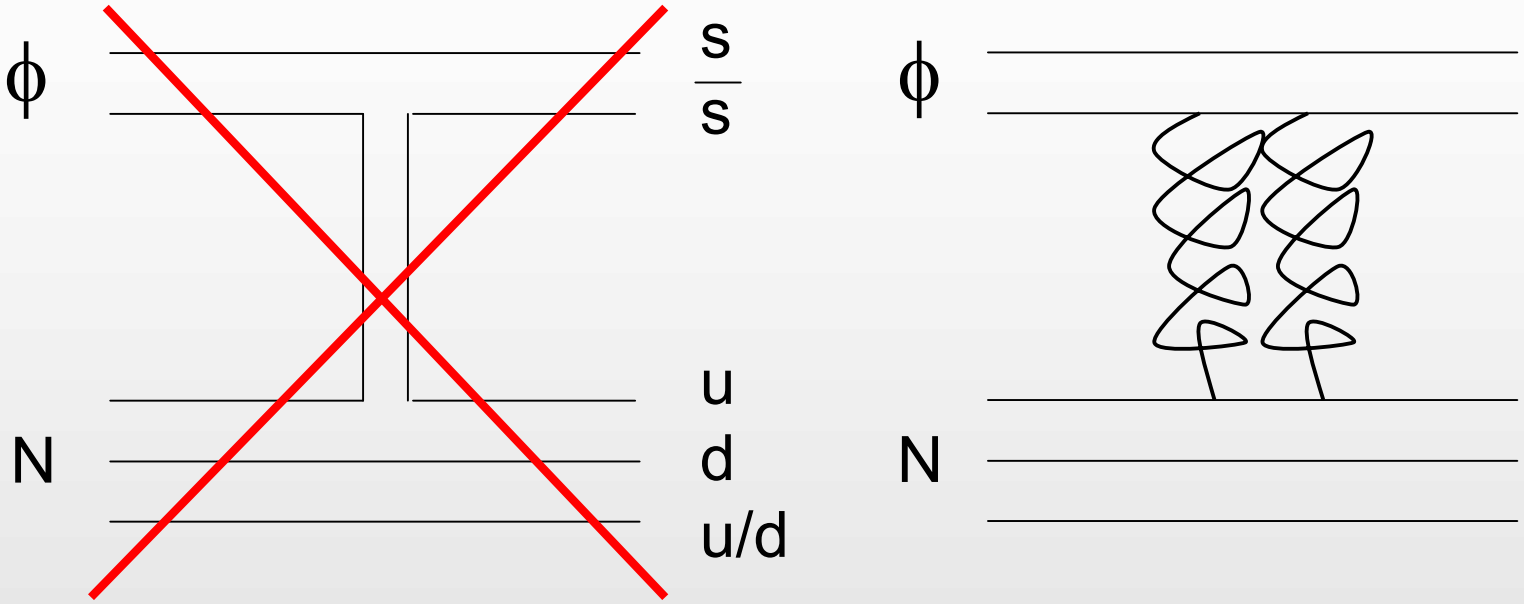
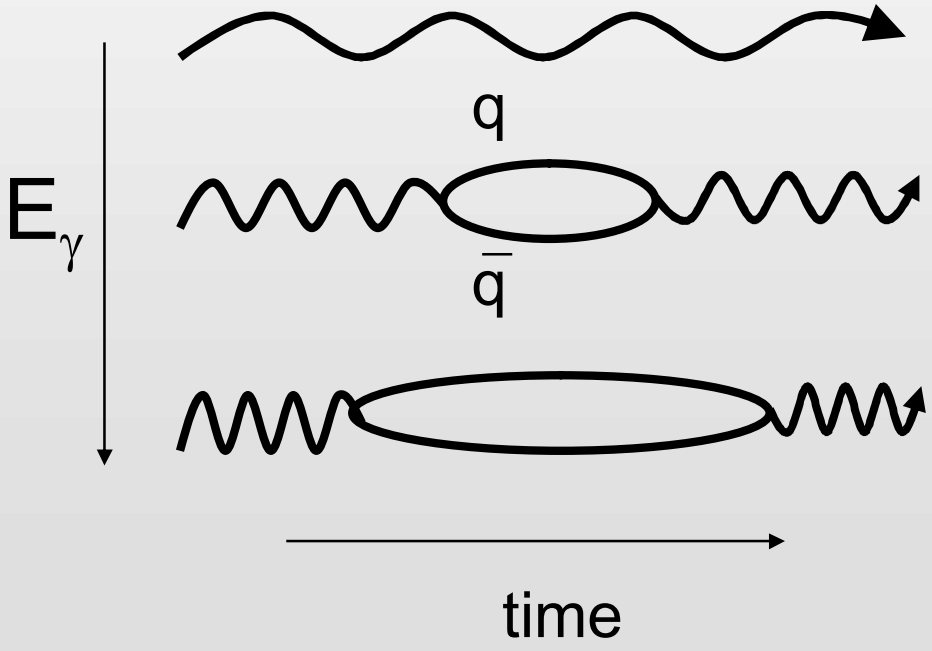
ϕ-nucleon interactions



- Contributions from quark exchanges are suppressed.
- Unique place to study multi-gluon exchange processes.
- Not well-studied because of difficulties in making ϕ-meson beam.

Vector Meson Dominance (VMD)

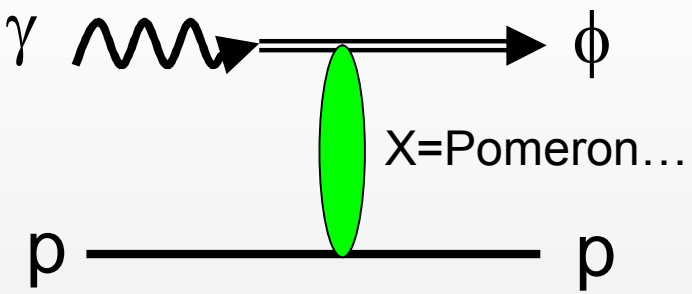
- Photon $J^{PC} = 1^{--}$
- Vector mesons ($\rho,\omega,\phi,J/\psi$ ...) $J^{PC} = 1^{--}$



$$\Delta t \approx \frac{2E_\gamma}{m_{VM}^2} \approx 1\,fm/c$$

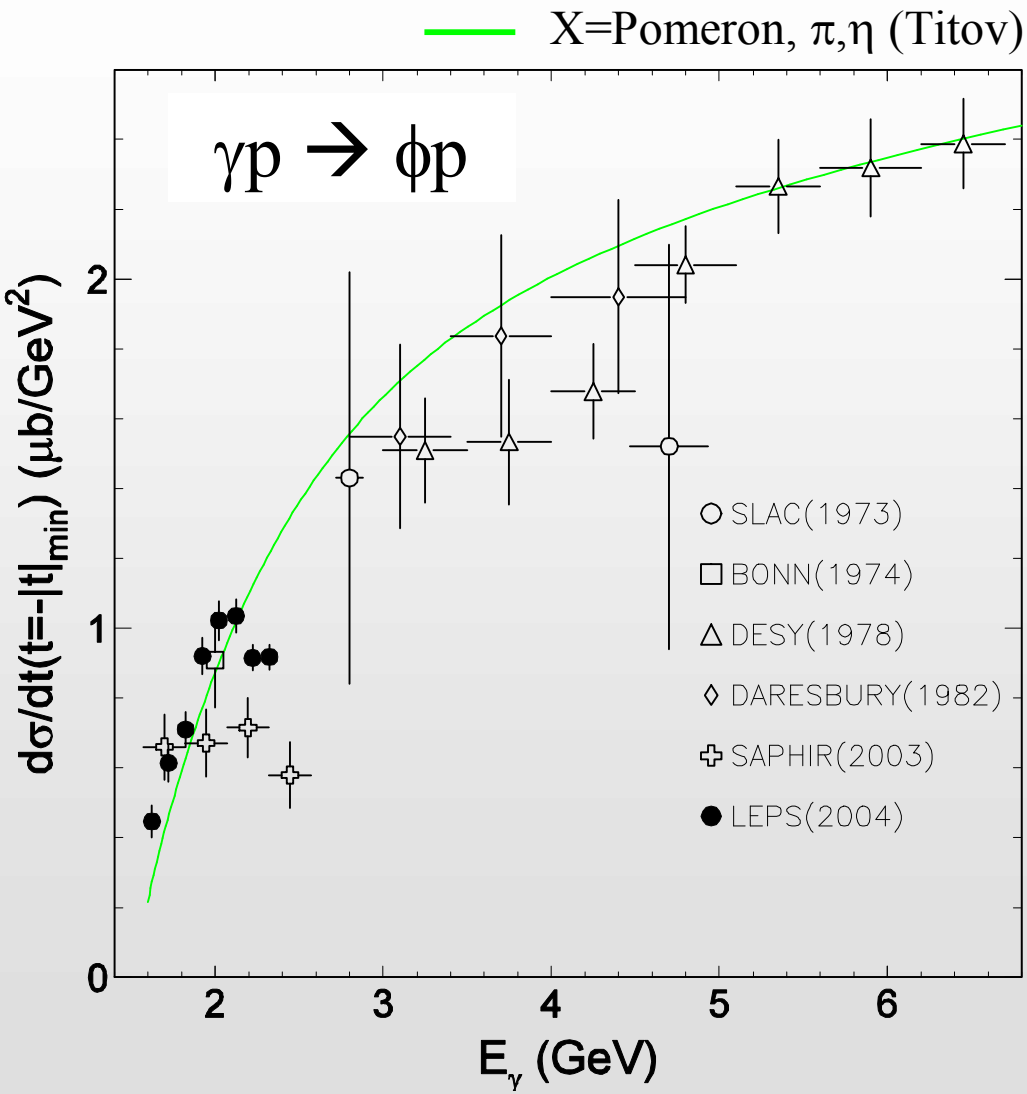
for ϕ-meson,
E_γ=3 GeV

Diffreactive ϕ photoproduction on proton



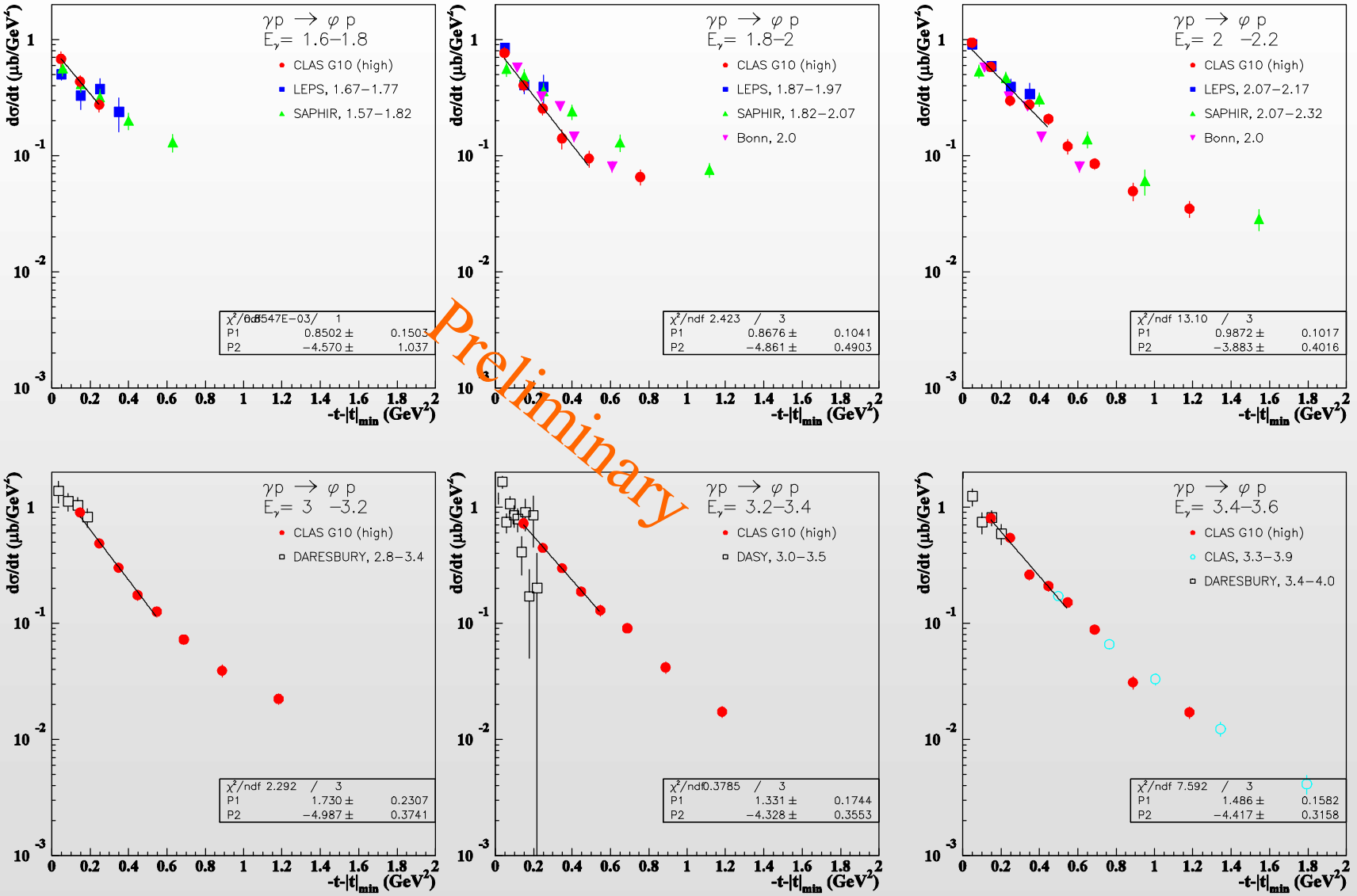
E_γ dependence
is not understood
by the theory

LEPS/SAPHIR
inconsistency



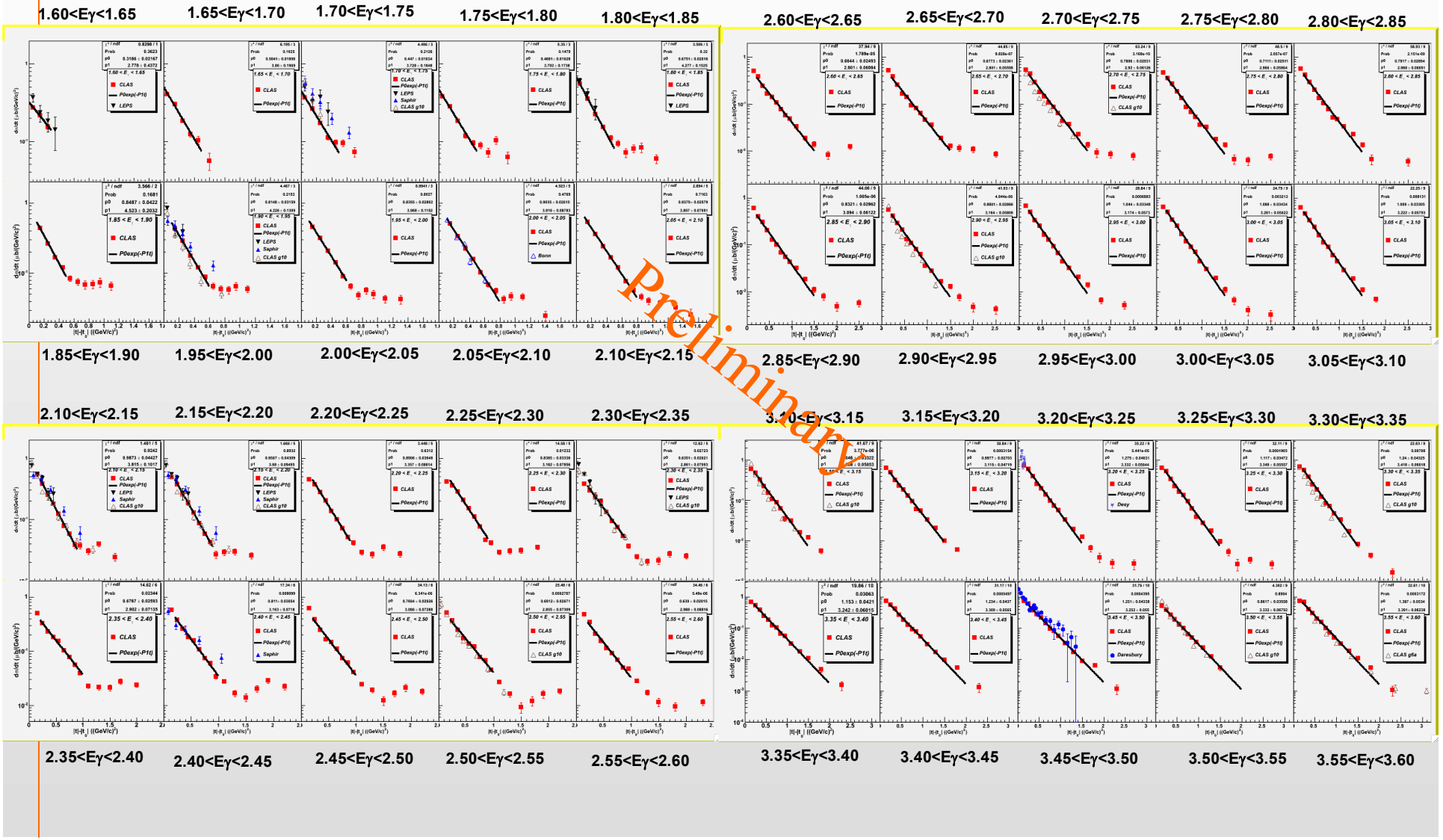
CLAS g10 proton data

$\gamma p \rightarrow \phi p$

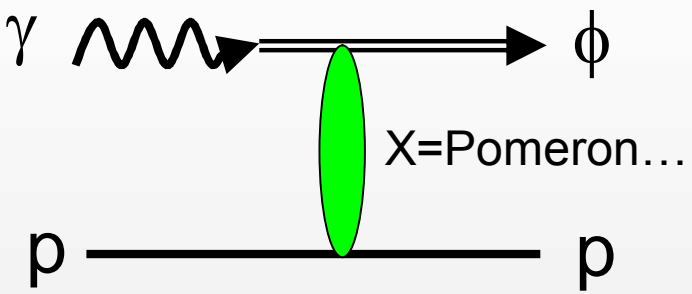


CLAS g11 proton data

$\gamma p \rightarrow \phi p$

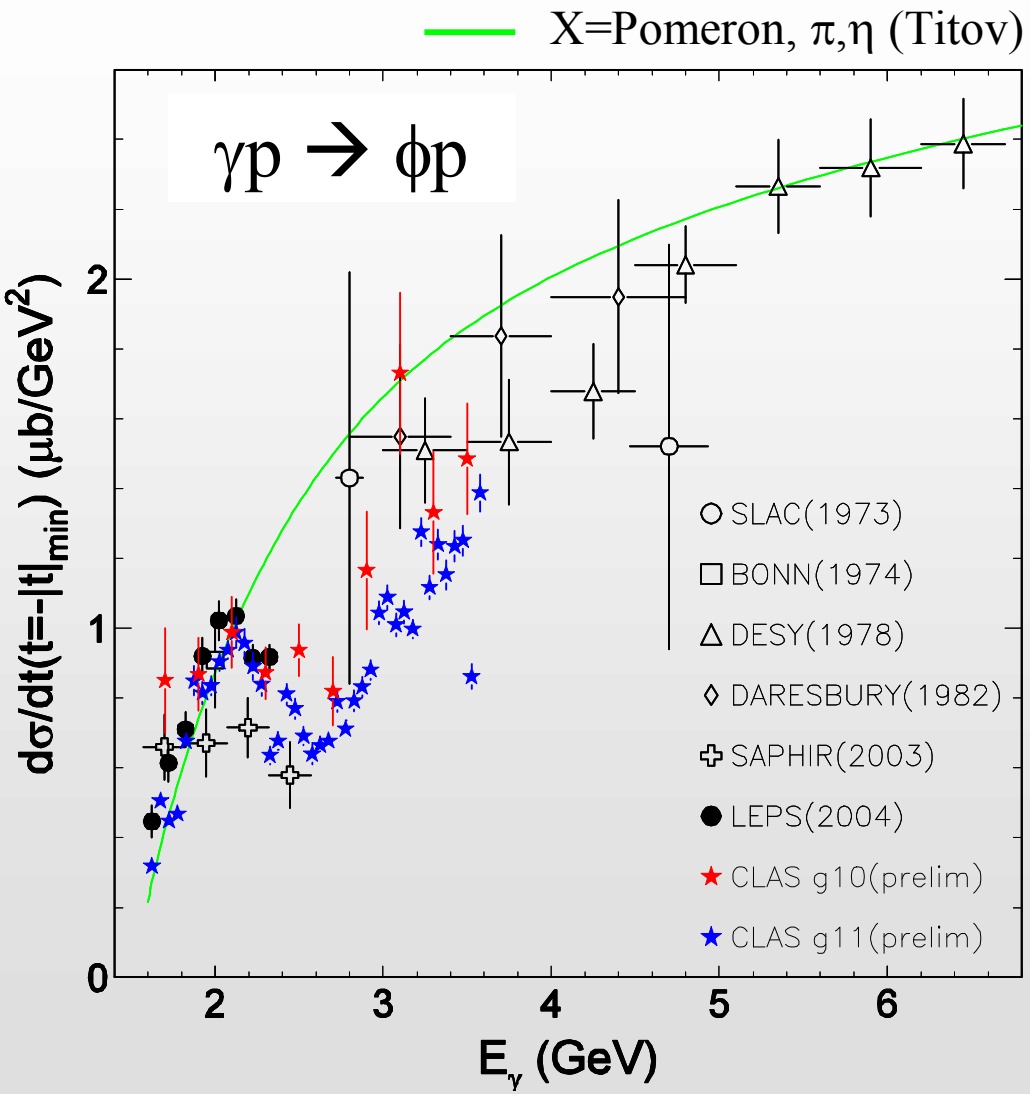


Diffreactive ϕ photoproduction on proton



New results from two independent data from CLAS.

Good consistency with LEPS data.



At LEPS2

- Improved mesurements of $d\sigma/dt$ at $t=-|t|_{min}$ with proton target
  - Wide energy range (E_γ=1.6-6 GeV)
  - Without extrapolation from larger −t
  - Good forward-angle coverage is essential (challenging to current/future facilities at Jlab)
- Coherent production off of deuteron (I=0)
  - Isospin filtering
  - Extension of current efforts by Chang, Horie, Shimizu et al.

VMD and total ϕN cross section

- Vector meson dominance

  $T_{\gamma N \to \phi N} = \alpha_{\gamma\phi}\, T_{\phi N \to \phi N}$

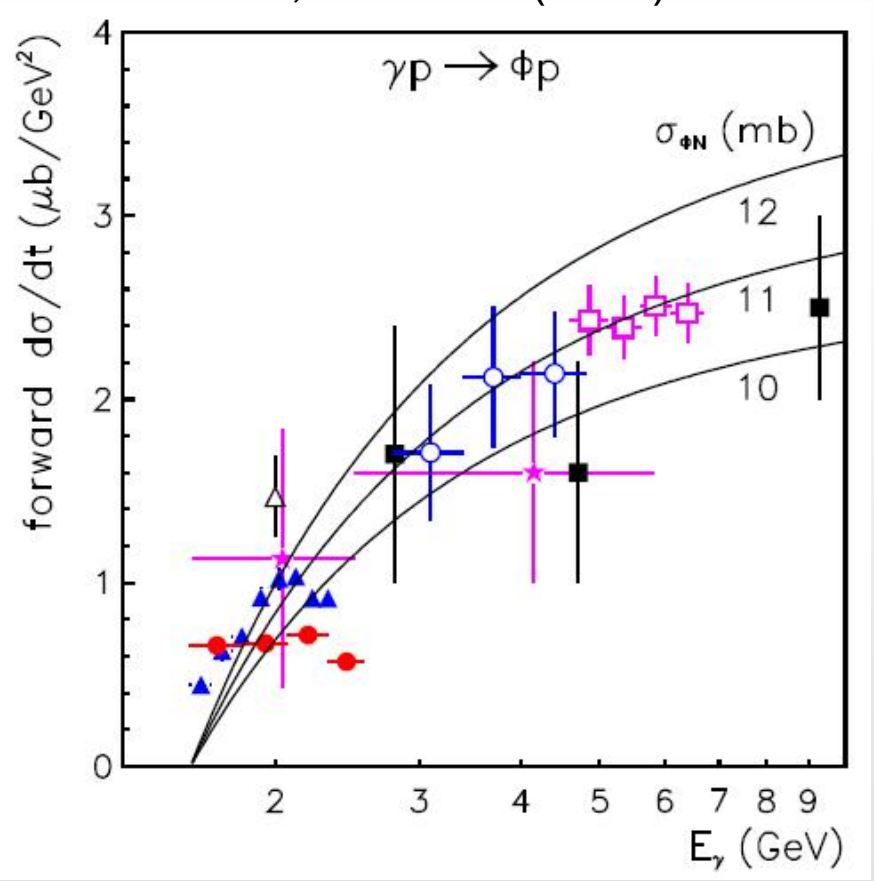
- Optical theorem

  $\sigma_{\phi N} = 4\pi\, \mathrm{Im}(T_{\phi N \to \phi N})$

- Diff. cross section at t=0

$$\left.\frac{d\sigma_{\gamma N \to \phi N}}{dt}\right|_{t=0} = \alpha_{\gamma\phi}^2 \frac{p_\phi^2}{p_\gamma^2}\left(1-\beta^2\right)\sigma_{\phi N}^2$$

Sibirtsev et al.,EPJ. A 29 (2006) 209



- VMD estimate, $\sigma_{\phi N}$ ~10-12 mb

$\sigma_{\phi N}$ from A dependence

- $\sigma_{\phi N}^{inel}$ is measured by a nuclear transmission factor (T_A) from A-dependence:

$$T_A = \frac{\sigma_{\gamma A \to \phi X}}{A \sigma_{\gamma N \to \phi X}}$$

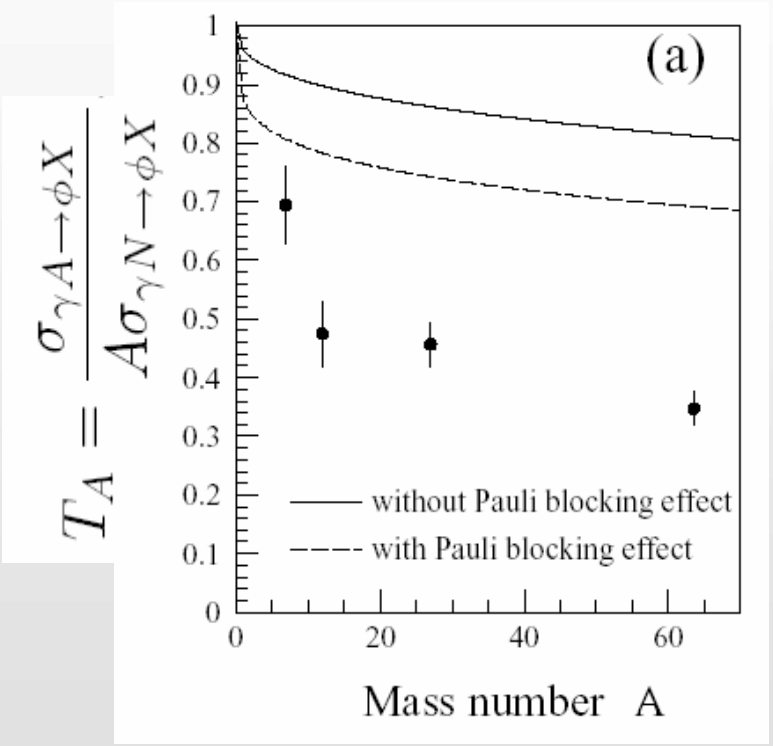
- LEPS data (E_γ=1.6-2.4 GeV) on A-dependence:

  $\sigma_{\phi N}^{inel} = 35^{+17}_{-11}$ mb

- Much larger than VDM estimate

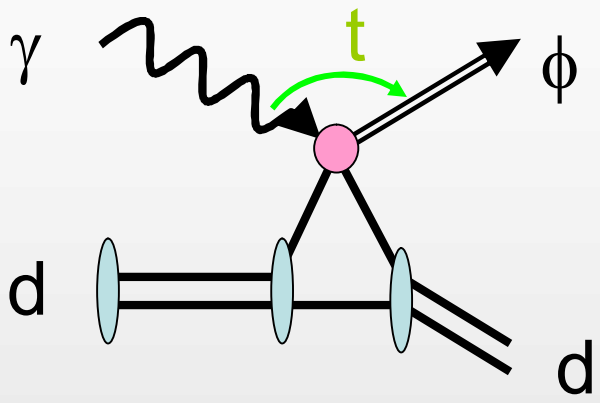
  $\sigma_{\phi N} = \sigma_{\phi N}^{el} + \sigma_{\phi N}^{inel} = 10\text{-}12$ mb

T. Ishikawa et. al (LEPS)
Phys.Lett. B608 (2005) 215

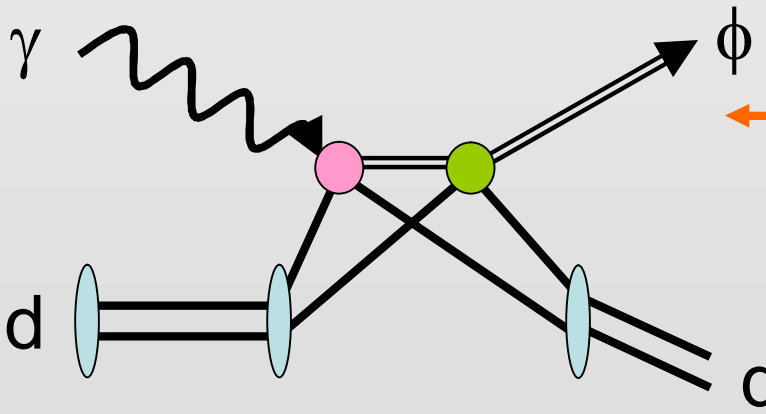


Coherent ϕ-meson photo-production on deuterium

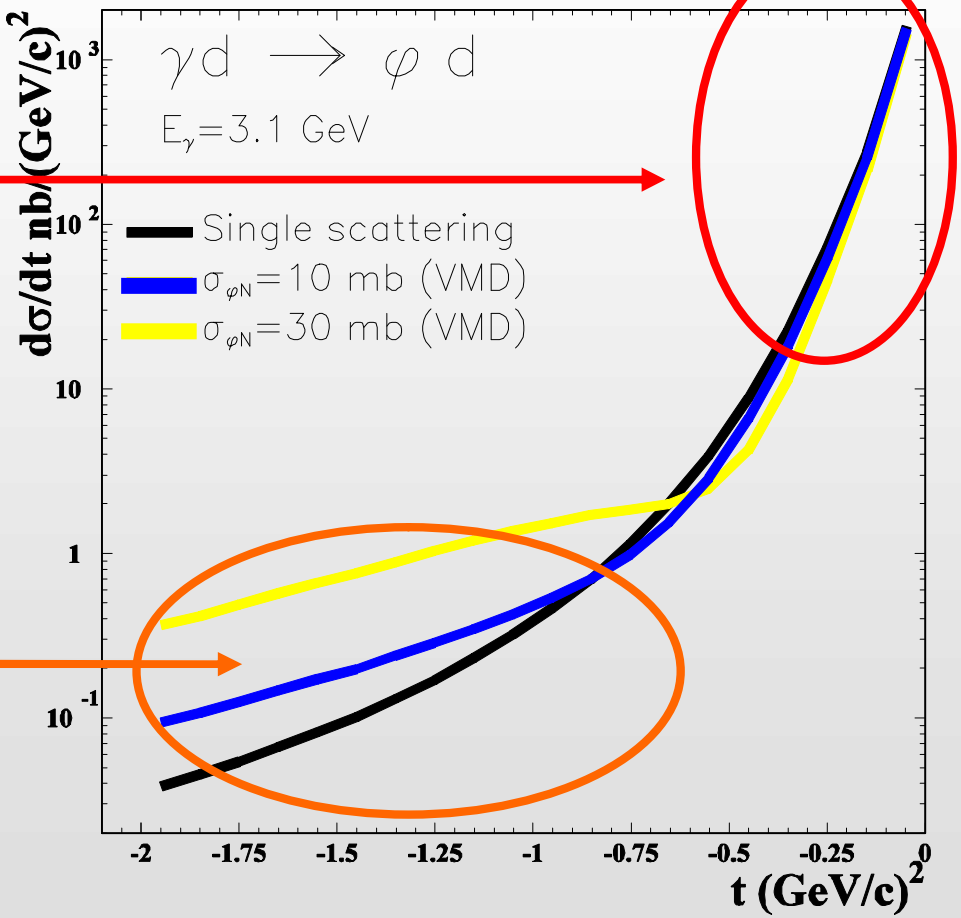
- Single scattering



- Double scattering

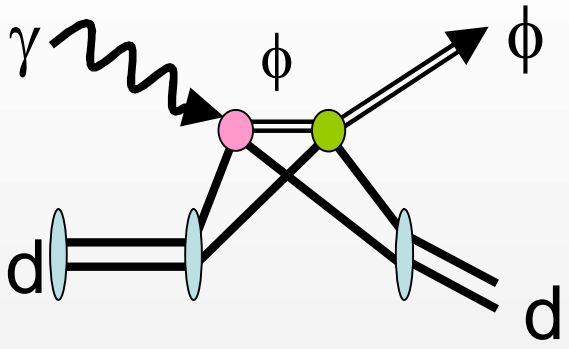


Model: T. Rogers, M. Sargsian, M. Strikman
NPA622,511(1997), PRC73, 04502 (2006)



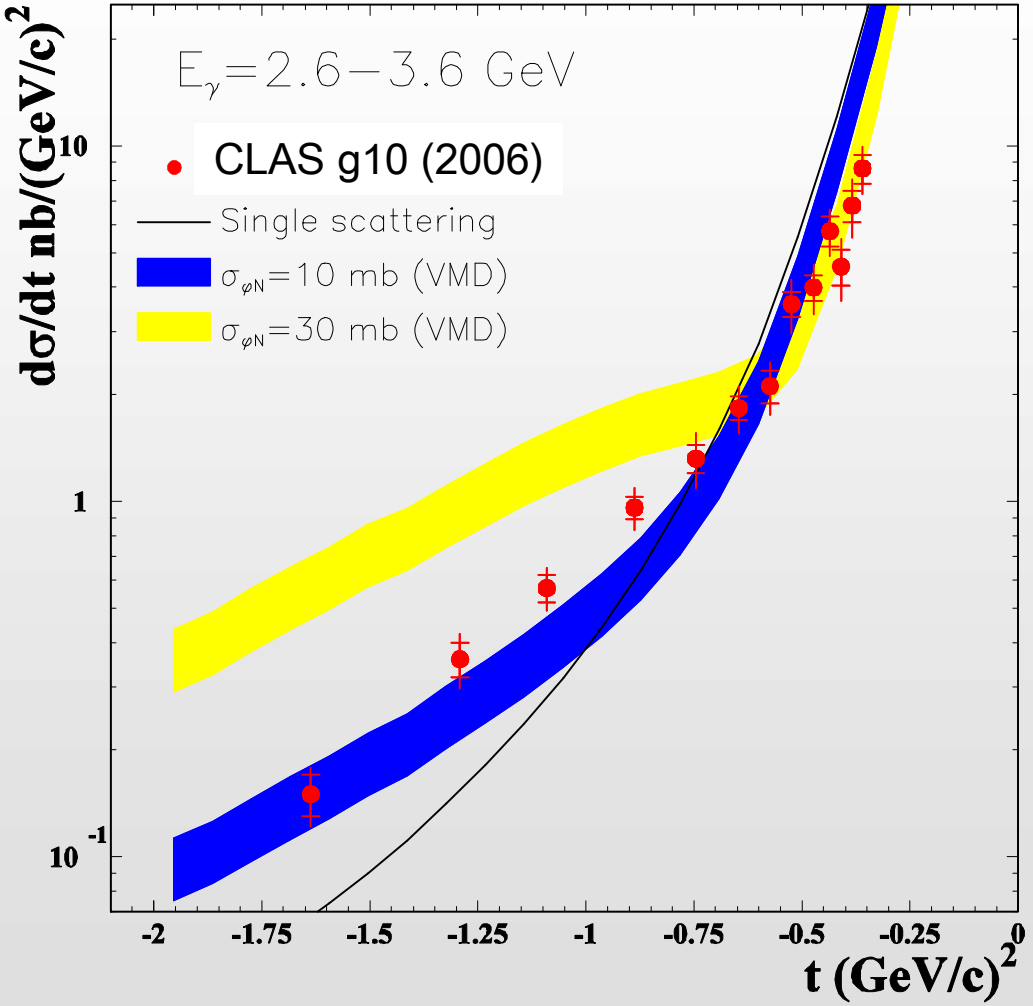
Same model successfully describes ρ–meson data with known $\sigma_{\rho N}$

Coherent ϕ-meson photo-production on deuterium

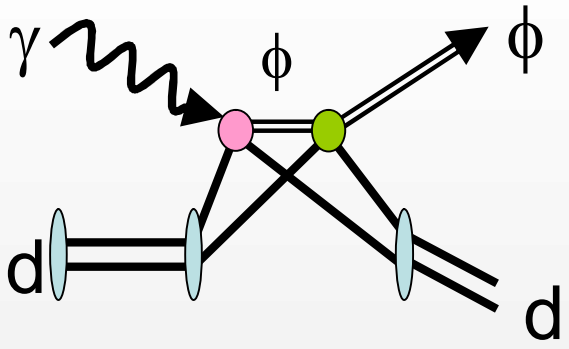


- Vector Meson Dominance
- $T_{\gamma N \to \phi N} = \alpha_{\gamma\phi}\, T_{\phi N \to \phi N}$

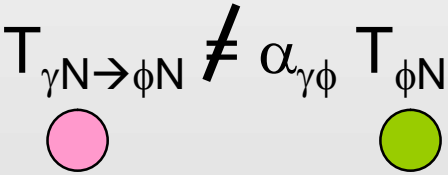
No experimental justification at low energy



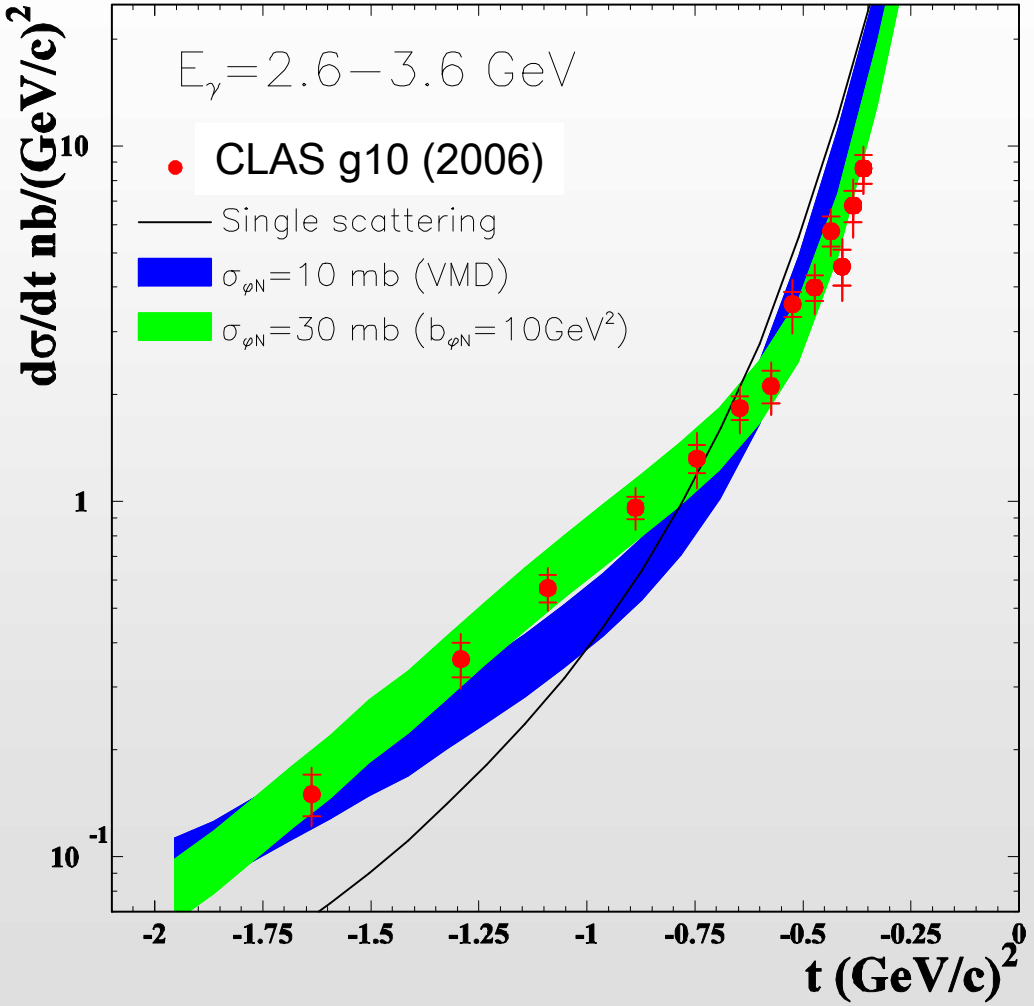
Coherent ϕ-meson photo-production on deuterium



- Non-VDM case
- $T_{\gamma N \to \phi N} \neq \alpha_{\gamma\phi}\, T_{\phi N \to \phi N}$



- $T_{\phi N \to \phi N} = \sigma_{\phi N}(i+\beta)e^{b/2\, t}$

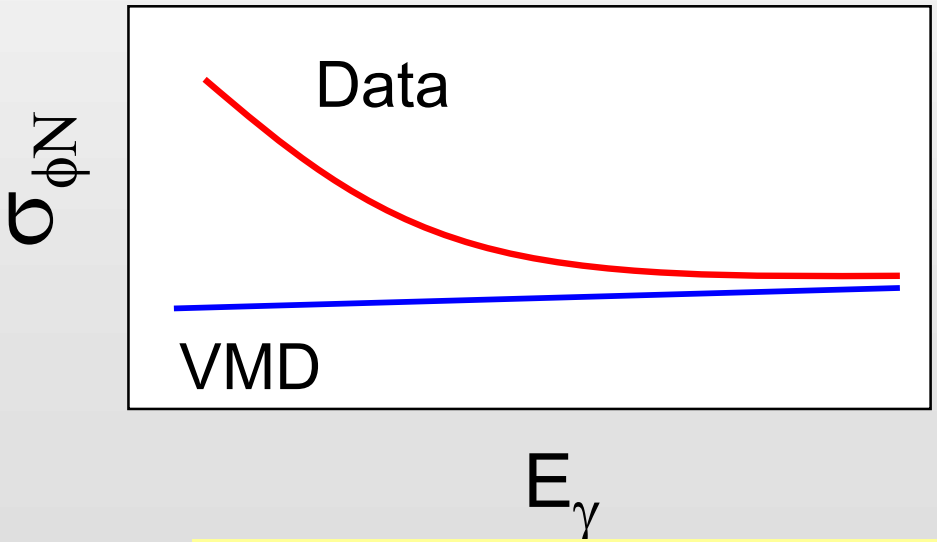


ϕ-N cross section

- Tantalizing difference in $\sigma_{\phi N}$ estimated from γp data (10-12mb) and LEPS γA data (~30mb).
- New CLAS deuteron data
  - Data is consistent with 10mb in the framework of VMD. Inconsistency with γA data remains.
  - Larger $\sigma_{\phi N}$ from γA data can be understood if the t-slope for the reaction ϕN→ϕN is larger than the reaction γp→ϕp.
- Larger t-slope → Larger interaction radious (cross section)
  - Are we really measuring $\sigma_{\phi N}$?
  - If so, what makes ϕ-meson fat ?
- Apparently, there is something beyond the VMD picture.

At LEPS2

- Photon energy dependence of ϕ meson absorption in nucleus
  - Extension to previous γA measurement (by Ishikawa et al., E_γ<2.4 GeV)
  - VMD should work better at higher photon energy.



$$\Delta t \approx \frac{2E_\gamma}{m_{VM}^2}$$

If multi-step process like γN→ωN,ωN→ϕN were important, data would never reach the VMD value.

Summary

- Two mysteries as of 2004
  - E_γ dependence of $\gamma p \rightarrow \phi p$ cross section in LEPS γp data
  - Larger $\sigma_{\phi N}$ in LEPS γA data
- CLAS is in the game now. New results from CLAS make things clearer. But not yet fully understood.
- LEPS2 could make major contribution to the issues of ϕ-N interaction.

Lead investigators

- H.Gao (Duke), K.Hicks (Ohio), K.Kramer (Duke), T.Mibe (Ohio), S.Stepanyan (Jlab), D. Tedeschi (USC).
- and the CLAS collaboration

- Theoretical supports from
  - T.Rogers, M.Strikman (PSU), M.Sargsian (FSU)
  - A. Titov (RIKEN,JINR)
  - J-M. Laget (CEA Saclay)